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Original scientific paper

FATTY ACID COMPOSITION OF VARIOUS SOYBEAN PRODUCTS

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ABSTRACT: The use of soybean products in feed and food industry has increased steadily over the past decade. According to its end uses, it can be classified as oil bean and food bean. A wide rage of processes is known today, in aim to produce large variety of soybean products for human and animal nutrition. The aim of the study presented in this paper was to investigate fatty acid composition in soybean and various soybean products, and to get overall picture about their nutritional suitability, regarding fatty acid composition. Whole bean of soy, soybean oil, soybean cake and soybean grits were investigated. Total fat content was extracted from the samples by supercritical fluid extraction with CO_2, and fatty acid profile was determined on gas chromatograph equipped with flame ionization detector. Most prevalent fatty acids in soybean and soybean products, except in soybean oil, were C18:2ω-6, C18:1, and C18:3ω-3. All examined samples have had PUFA/SFA ratio higher than 0.4, and thus, soybean and its products can be considered as favorable. Examined soybean and soybean products have had ω–6/ω–3 ratio higher than 4 (preferred ratio is less than 4), and therefore cannot be used as the only source of fatty acids in human and animal nutrition.

Key words: *fatty acid, soybean, soybean products*

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INTRODUCTION

Soybean (*Glycine* max (L.) Merrill) originated from China, where it is considered the oldest agricultural crop. It is known in Europe for over 200 years. A large number of soybean varieties exist, producing soybeans that vary greatly in shape and colour (Karlović and Andrić, 1996). The soybean consist of two cotyledons which represent approximately 90% of the weight, a seed coat of hull (8% of weight), and two much smaller and lighter structures, the hypocotyls and the plumule (Van Eys et al., 2004). The mature soybean is about 38% protein, 30% carbohydrate, 18% oil, and 14% moisture, ash, and hull. Soybeans contain all three of the macro-nutrients required for good nutrition: complete protein, carbohydrate and fat, as well as vitamins and minerals, including calcium, folic acid, and iron (Sauvant et al., 2004).

The use of soybean products in feed and food industry has increased steadily over the past decade. Soybean is especially interesting because of its non-gluten proteins (Torbica et al., 2008). A large array of different manufacturing processes is applied to obtain the many soy products used in animal and human nutrition (Berk,1992). Soybean can be classified into oil bean and food bean according to its end uses. Oil

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soybean, i.e. commodity bean, is the primary source of vegetable oil and soy protein products, such as defatted soy flour and soy protein concentrate (Van Eys et al., 2004). Graphic illustration of process production of various products is shown in Figure 1 (Van Eys et al., 2004). Soybean cake is the product gained from pressing of soybean, with 15% of proteins soluble in water. Soybean grit is the meal product resulting from extrusion of whole soybeans without removing any of the component parts (Pravilnik o kvalitetu hrane za životinje, 2009).

Recently, there has been growing interest for fatty acid composition of food, since there has been reported a great influence of these components on human health. The beneficial health effects of ω-3 fatty acids were described first in the Greenland Eskimos (Rose et al., 1999) who consumed a diet rich in seafood and had low rates of coronary hearth disease, asthma, type 1 diabetes mellitus, and multiple sclerosis, since that observation, the beneficial effects of ω-3 fatty acids have been extended to include benefits related to cancer, inflammatory bowel disease, rheumatoid arthritis, and psoriasis (Rose et al., 1999; Connor, 2000; Simopoulos, 2002; Simopoulos, 2008). At the same time increased levels of ω-6 fatty acids are associated with an increase in chronic diseases (Givens et al., 2006). However, these beneficial, health promoting effects are limited by the fact that the modern Western diet is rather low in ω-3 fatty acids and is very high in ω-6 fatty acids content (Enser et al., 2000).

The aim of the study presented in this paper was to investigate fatty acid composition in soybean and various soybean products, and to obtain overall picture about their nutritional suitability, from the point of fatty acids.

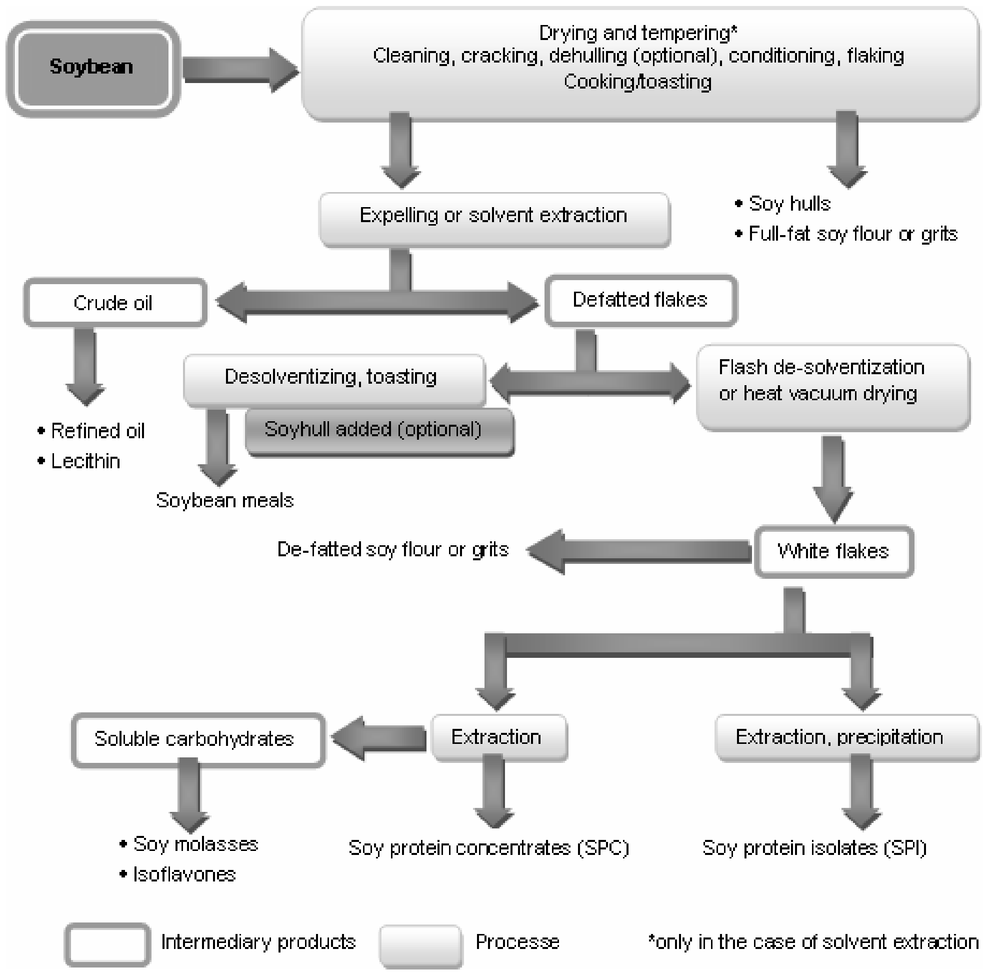

Figure 1. Schematic presentation of the manufacturing of soybean products (Van Eys et al., 2004)

MATERIAL AND METHODS

Three samples of each analyzed product: whole soybean seed, soybean oil, soybean cake and full-fat soybean grits, comercially available on the market, were analyzed in aim to determine complete fatty acid profiles of soybean products. Fats were extracted by using supercritical fluid extraction (SFE) with CO_2, and further analysis were done by gas chromatograph equipped with flame ionization detector (GC-FID).

Supercritical fluid extractions

LECO TFE-2000 fat analyzer (LECO, St. Joseph, MI, USA) was used for SFE, using CO_2 with a purity of 99.995%. Temperature, extraction flow rates and pressure were adopted from existing LECO procedures. Cell temperature and heated variable restrictor (HVR) temperature were set at 100 ºC and 110 ºC, respectively. The collection vials on the instrument remained near room temperature of 25 ºC Extracting pressure was 7500 psi, and extraction flow rate was 1.3 l/min. (Organic application note, 2003). “Leco Dry” infusorial soil was used as absorbent for removing traces of water from samples in amount of 2g per 1g of sample. Static extraction time was set on 0 minute, and dynamic extraction time was set on 60 minutes.

1.0 g of homogenized milled sample was weighed into glass baker with accuracy of ±0.001 g. Targeted mass of absorbent was added to the baker and the sample was vigorously dispersed with a glass rod. This way prepared mixture was transferred into a metal extraction thimble (12 cm length and 10 mm diameter). Filled extraction thimbles were closed with approximately 0.5 g of glass wool on the top and appropriate cap. Glass scintillation vials (Wheaton, Millville, NJ, USA) were used as vessels for collecting extracted fat. Prepared thimbles and collection vials were placed in the instrument. After finishing the extraction step, the instrument was depressurized, and the collection vials were removed from the instrument. Next step was de-gassing of extracted fat in collection vials for ten minutes, and achieving constant weight of the extract. Fat content was expressed as percent by weight.

Fatty acid determination

Fatty acid methyl esters were prepared from the extracted lipids with method that use boron trifluoride/methanol solution, as recommended method for this type of substrates (Karlović and Andrić, 1996). Nitrogen gas was used for drying and removing solvents from fatty acid methyl esters. Obtained samples were analyzed by a GC Agilent 7890A system with FID, autoinjection module for liquid, equipped with fused silica capillary column (DB-WAX 30 m, 0.25 mm, 0.50 um). Helium was used as a carrier gas (purity > 99.9997 vol %, flow rate = 1.26 ml/min). The fatty acids peaks were identified by comparison of retention times with retention times of standards from Supelco 37 component fatty acid methyl ester mix and with data from internal data library, based on previous experiments. Results were expressed as mass of fatty acid or fatty acid group (g) in 100 g of fatty acids.

RESULTS AND DISCUSSION

The results of fatty acid analysis by GC-FID are shown in table 1. As it can be seen from the results, most prevalent fatty acids in soybean and soybean products, except in soybean oil, are C18:2ω-6, C18:1, and C18:3ω-3, respectively. These results are expected and in consistence with other literature data (Sauvant et al., 2004, Karlović and Andrić, 1996). In soybean oil, there has been higher concentration of C16:0 palmitic fatty acid, which is also common, and it could be consequence of soybean oil production process.

SFAs have been generally labeled as the cause of cancers and coronary heart disease. The mean ratio of PUFA/SFA recommended by the British Department of Health is more than 0.45, and WHO/FAO experts have reported guidelines for a “balanced diet” in which suggested ratio of PUFA/SFA is above 0.4 (Wood et al., 2008; Wood et al., 2003; HMSO, 1994). From this aspect, all examined samples have had favorable (from 2.49 to 12.02) PUFA/SFA ratio (Figure 2).

Table 1.
Fatty acid composition (% w/w) of soybean and various soybean products

fatty acid	soybean	soybean oil	soybean cake	full-fat soybean grit
C10:0	ND	ND	0,17 ± 0.15	0,10 ± 0.06
C14:0	ND	ND	0,04 ± 0.36	0,05 ± 0.31
C16:0	3,28 ± 0.12	16,95 ± 0.09	3,07 ± 0.16	3,11 ± 0.11
C18:0	2,34 ± 0.23	5,15 ± 0.32	2,41 ± 0.08	2,53 ± 0.23
C18:1	20,47 ± 0.51	16,02 ± 0.21	20,90 ± 0.23	22,22 ± 0.29
C18:2ω-6	68,02 ±0.06	47,57 ± 0.15	67,08 ± 0.54	65,82 ± 0.39
C18:3 ω-3	5,18 ± 0.13	12,11 ± 0.17	5,78 ± 0.33	5,57 ± 0.15
C20:0	0,71 ± 0.4	1,40 ± 0.3	0,20 ± 0.63	0,21 ± 0.35
C20:1	ND	0,42 ± 0.41	0,18 ± 0.45	0,20 ± 0.12
C22:0	ND	0,39 ± 0.18	0,17 ± 0.22	0,18 ± 0.41
SFA	6.33	23.89	6.06	6.18
MUFA	20.47	16.44	21.08	22.42
PUFA	73.2	59.68	72.86	71.39
MUFA/SFA	3.23	0.69	3.48	1.09
PUFA/SFA	11.56	2.49	12.02	11.55
∑ ω -6	68.02	47.57	67.08	65.82
∑ ω -3	5.18	12.11	5.78	5.57
ω-6/ ω -3	13.13	3.92	11.61	11.82

Results are given as mean ± standard deviation (n = 3); SFA - saturated fatty acid; MUFA - monounsaturated fatty acids; PUFA – polyunsaturated fatty acids

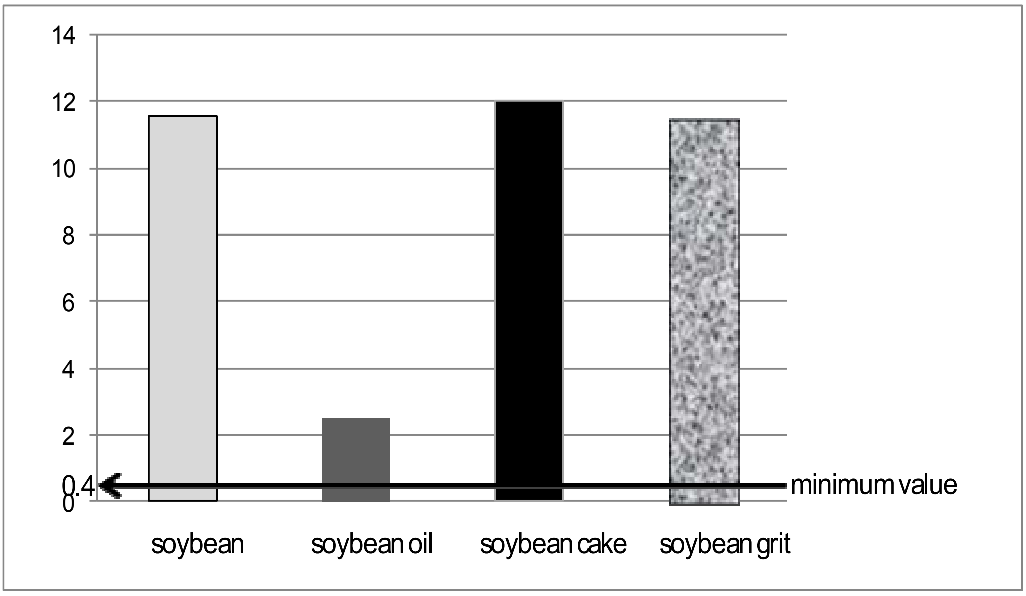

Figure 2. PUFA/SFA ratio in examined samples

It has been estimated that the present Western diet is deficient in ω-3 fatty acids, with a ratio of ω-6 to ω-3 of 15-20/1, instead of 1/1 as is the case with wild animals and presumably human beings (Simopoulos, 2008). Nutritional advice for today's ω-6/ω-3 ratio is less than 4 (Scollan et al., 2006). Examined soybean and soybean products have had ω–6/ω–3 ratio higher than 4, as it can be noticed on Figure 3, except for the soybean oil (3.92). Lower ω-6/ω-3 ratio in soybean oil is not the rule in practice, and it could be result of different soybean type, in this particular case. Therefore, soybean cannot be used as the only source of fatty acids in human nutrition (probably also in animal nutrition), and have to be combined with other food, rich in ω-3 fatty acids.

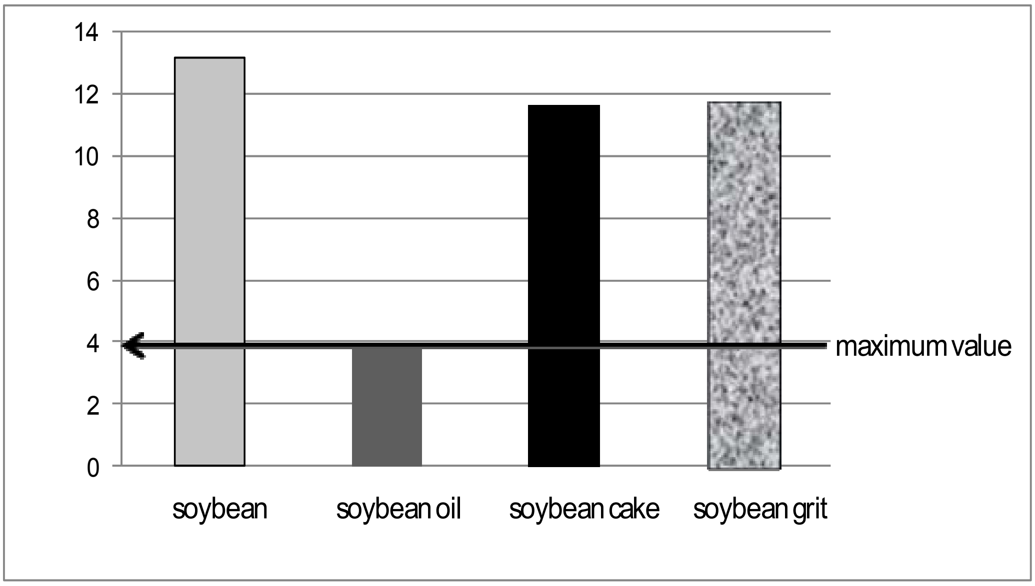

Figure 3. ω–6/ω–3 ratio in examined samples

CONCLUSIONS

If we look at fatty acid composition, they are partially suitable for food and feed usage and cannot be used as the only source of fat in the diet. Whole soy bean, as well as soybean oil, soybean cake, and soybean grits have had PUFA/SFA ratio higher than 0.4 (from 2.49 to 12.02), which is the minimum ratio recommended from WHO/FAO organization. On the other side, ω–6/ω–3 ratio was higher than 4, and it is limitation factor for independent usage from other fat source. Knowing this and taking it into account soybean and its products have an important role in today's human and animal nutrition.

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САСТАВ МАСНИХ КИСЕЛИНА РАЗЛИЧИТИХ ПРОИЗВОДА ОД СОЈЕ

Душица Иванов, Јованка Левић, Славица Средановић

У протеклој деценији, употреба соје и сојиних производа константно је расла, како у исхрани људи, тако и у исхрани животиња. Данас је познат читав низ производних процеса, који се примењују у преради сојиног зрна ради добијања различитих производа, који се употребљавају у прехрамбеној индустрији и индустрији хране за животиње. Циљ овог рада био је да се испита маснокиселински састав различитих производа од соје, како би се стекла слика о њиховој нутритивној подобности, с аспекта садржаја масних киселина. Испитивани су цело зрно соје, сојино уље, сојина погача и сојин гриз. Укупне масти су екстраховане из узорака применом суперкритичне флуидне екстракције са CO_2, а маснокиселински профил је одређен на гасном хроматографу са пламено - јонизујућим детектором. Најзаступљеније масне киселине у свим узорцима, осим у сојином уљу су C18:2ω-6, C18:1 и C18:3ω-3. Сви узорци имали су однос PUFA/SFA већи од 0,4, што се сматра пожељним за прехрамбене производе. Однос ω–6/ω-3 масних киселина у узорцима био је већи од 4 (препоручљиво је да овај однос има вредности мање од 4), па се стога соја, као ни производи од соје не могу користити као једини извор масних киселина у исхрани људи и животиња.